We claim:

1. A gas sensor, comprising:

a first electrode and a reference electrode with an electrolyte disposed therebetween, wherein the first electrode and reference electrode are in ionic communication; and

a reference gas channel in fluid communication with the reference electrode and an exterior of the sensor, wherein the reference gas chamber has a diffusion limiter.

2. A gas sensor as in Claim 1, wherein the reference gas channel has a limiting exhaust flux of about 30 mA/cm^2 or less of reference electrode area.

3. A gas sensor as in Claim 2, wherein the reference gas channel has a limiting exhaust flux of about 20 mA/cm^2 or less of the reference electrode area.

4. A gas sensor as in Claim 3, wherein the reference gas channel has a limiting exhaust flux of about 10 mA/cm^2 or less of the reference electrode area.

5. A gas sensor as in Claim 3, wherein the reference gas channel has a size determined by Equation (I):

$$F_{exh} = \frac{DCA}{L} \qquad \text{(I)}$$

where F_{exh} is the exhaust gas flux (i.e., the rate of exhaust gas migration through the channel); D is the diffusion constant of exhaust; C is the ambient atm. fuel concentration at the open end of the reference gas channel; A is the average cross-sectional area of the gas channel; and L is the length of the gas channel.

6. A gas sensor as in Claim 5, wherein design of the reference gas channel is further based upon Equation (II):

$$I_p = \frac{V_h \cdot V_{emf}}{R} \qquad \text{(II)}$$

where I_p is pump current; V_h is heater voltage; V_{emf} is sensor emf; and R is resistor resistance.

7. A gas sensor as in Claim 1, wherein the reference gas channel has a length of about 35 mm to about 65mm, a width of about 0.50 mm or less, and a height of about 0.05mm or less.

8. A gas sensor as in Claim 7, wherein the length is about 35mm to about 50mm, the width is about 0.30mm or less, and the height is about 0.025mm or less.

9. A gas sensor as in Claim 8, wherein the length is about 40mm to about 48mm, the width is about 0.13mm or less, and the height is about 0.015mm or less.

10. A gas sensor as in Claim 1, wherein the reference gas channel further comprises an oxygen storage material.

11. A gas sensor as in Claim 10, wherein the oxygen storage material is selected from the group consisting of platinum, rhodium, palladium, ruthenium, iridium, osmium, cerium oxide, bismuth oxide, and mixtures and alloys comprising at least one of the foregoing materials.

12. A gas sensor as in Claim 1, wherein the reference gas channel further comprises a first chamber disposed adjacent to the reference electrode, wherein the first chamber has a cross-sectional area greater than a diffusion limiter cross-sectional area.

13. A gas sensor as in Claim 12, wherein the reference gas channel further comprises a second chamber further comprises a second chamber and a second diffusion path, wherein the second chamber is disposed in fluid communication with the first chamber, with the first diffusion path disposed therebetween, and the second diffusion path is disposed in fluid communication with the first diffusion path, with the second chamber disposed therebetween, and the second chamber has a cross-sectional area greater than the first chamber cross-sectional area and the second diffusion path has a cross-sectional area smaller than the first chamber cross-sectional area.

14. A gas sensor as in Claim 1, wherein the sensor further comprises a heater and a resistor, wherein the resistor is connected to a positive heater lead and to the reference electrode.

15. A gas sensor as in Claim 1, further comprising co-firing the sensor.

16. A method for operating a gas sensor, comprising:

using a gas sensor, the sensor comprising a first electrode and a reference electrode with an electrolyte disposed therebetween, wherein the first electrode and reference electrode are in ionic communication, and a reference gas channel in fluid communication with the reference electrode and an exterior of the sensor;

introducing an exhaust gas to the first electrode;

applying a voltage to the reference electrode;

ionizing oxygen at the first electrode;

transferring the ionized oxygen across the electrolyte to the reference electrode;

forming molecular oxygen at the reference electrode;

ionizing the molecular oxygen on the reference electrode;

transferring the ionized oxygen across the electrolyte to the first electrode to create a voltage; and

measuring the voltage.

17. The method for operating a gas sensor as in Claim 16, wherein the reference gas channel further comprises a diffusion limiter.

18. The method for operating a gas sensor as in Claim 16, wherein the reference gas channel has a limiting exhaust flux of about 30 mA/cm^2 or less of reference electrode area.

19. The method for operating a gas sensor as in Claim 18, wherein the reference gas channel has a limiting exhaust flux of about 20 mA/cm^2 or less of the reference electrode area.

20. The method for operating a gas sensor as in Claim 19, wherein the reference gas channel has a limiting exhaust flux of about 10 mA/cm^2 or less of the reference electrode area.

21. The method for operating a gas sensor as in Claim 16, wherein the reference gas channel has a size determined by Equation (I):

$$F_{exh} = \frac{DCA}{L} \qquad \text{(I)}$$

where F_{exh} is the exhaust gas flux (i.e., the rate of exhaust gas migration through the channel); D is the diffusion constant of exhaust; C is the ambient atm. fuel concentration at the open end of the reference gas channel; A is the average cross-sectional area of the gas channel; and L is the length of the gas channel.

22. The method for operating a gas sensor as in Claim 21, wherein design of the reference gas channel is further based upon Equation (II):

$$I_p = \frac{V_h \quad V_{emf}}{R} \qquad \text{(II)}$$

where I_p is pump current; V_h is heater voltage; V_{emf} is sensor emf; and R is resistor resistance.

23. The method for operating a gas sensor as in Claim 22, wherein the reference gas channel has a length of about 35 mm to about 65mm, a width of about 0.50 mm or less, and a height of about 0.05mm or less.

24. The method for operating a gas sensor as in Claim 23, wherein the length is about 35mm to about 50mm, the width is about 0.30mm or less, and the height is about 0.025mm or less.

25. The method for operating a gas sensor as in Claim 24, wherein the length is about 40mm to about 48mm, the width is about 0.13mm or less, and the height is about 0.015mm or less.

26. The method for operating a gas sensor as in Claim 16, wherein the reference gas channel further comprises an oxygen storage material.

27. The method for operating a gas sensor as in Claim 26, wherein the oxygen storage material is selected from the group consisting of platinum, rhodium, palladium, ruthenium, iridium, osmium, cerium oxide, bismuth oxide, and mixtures and alloys comprising at least one of the foregoing materials.

28. The method for operating a gas sensor as in Claim 16, wherein the reference gas channel further comprises a first chamber disposed adjacent to the reference electrode, wherein the first chamber has a cross-sectional area greater than a diffusion limiter cross-sectional area.

29. The method for operating a gas sensor as in Claim 29, wherein the reference gas channel further comprises a second chamber and a second diffusion path, wherein the second chamber is disposed in fluid communication with the first chamber, with the first diffusion path disposed therebetween, and the second diffusion path is disposed in fluid communication with the first diffusion path, with the second chamber disposed therebetween, and the second chamber has a cross-sectional area greater than the first chamber cross-sectional area and the second diffusion path has a cross-sectional area smaller than the first chamber cross-sectional area.

30. The method for operating a gas sensor as in Claim 29, further comprising a heater electrically connected to the reference electrode, wherein a voltage is cyclically applied to the heater.

Rule 1.126

31. ~~32.~~ The method for operating a gas sensor as in Claim 16, wherein the operations of ionizing oxygen at the first electrode, transferring the ionized oxygen across the electrolyte to the reference electrode, and forming molecular oxygen at the reference electrode, occur substantially simultaneously with the operations of ionizing the molecular oxygen on the reference electrode, and transferring the ionized oxygen across the electrolyte to the first electrode to create a voltage.

32. ~~33.~~ The method for operating a gas sensor as in Claim 16, wherein the gas sensor further comprises a heater, and wherein the sensor has been co-fired.